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Remarks:

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(54) METHOD AND APPARATUS FOR UTILIZING MULTIPLE CARRIERS IN HIGH SPEED PACKET ACCESS COMMUNICATIONS

(57) A method and an apparatus for utilizing multiple carriers are disclosed. A wireless transmit/receive unit (WTRU) capable of receiving on a single downlink carrier at a time may tune the receiver to one downlink carrier and switch the downlink carrier in accordance with a configured pattern. The WTRU may switch the carrier from an anchor carrier to a non-anchor carrier at a high speed shared control channel (HS-SCCH) sub-frame boundary, and switches back at an end of a subsequent high speed

physical downlink shared channel (HS-PDSCH) sub-frame. The WTRU may switch the carrier at an HS-PDSCH sub-frame boundary. A WTRU capable of receiving on multiple downlink carriers simultaneously may tune the receiver to an anchor carrier and a supplementary carrier, and switch the supplementary carrier to another carrier based on a carrier switching order. The carrier switching order may be received via an HS-SCCH or via layer 2 signaling.

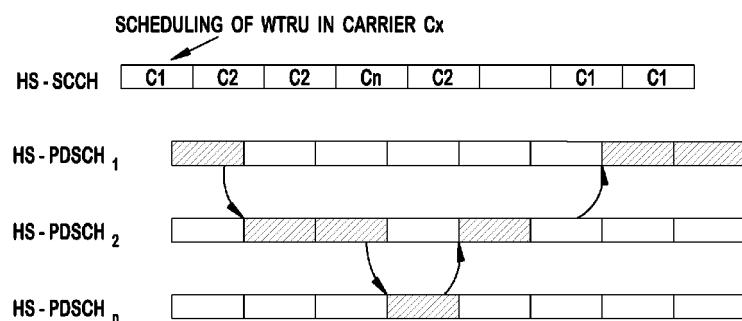


FIG. 7

Description**CROSS REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of U.S. provisional application No. 61/110,118 filed October 31, 2008, which is incorporated by reference as if fully set forth herein.

FIELD OF INVENTION

[0002] This application is related to wireless communications.

BACKGROUND

[0003] Dual-cell high speed downlink packet access (DC-HSDPA) has been introduced in the Release 8 specifications of the third generation partnership project (3GPP) for universal mobile telecommunication systems (UMTS). With this feature, base stations (also referred to as Node-Bs) communicate to wireless transmit/receive units (WTRUs) over two distinct carriers simultaneously. It not only doubles the bandwidth and the peak data rate available to the WTRUs, it also has a potential to increase the network efficiency by means of fast scheduling and fast channel feedback over two downlink carriers.

[0004] Figure 1 shows a medium access control (MAC) architecture for DC-HSDPA operations. The MAC layer architecture of DC-HSDPA includes one hybrid automatic repeat request (HARQ) entity per high speed downlink shared channel (HS-DSCH). This implies that HARQ re-transmissions take place over the same transport channel and thus somewhat restricts the benefit of frequency diversity potentially brought by the use of more than one downlink carrier if each HS-DSCH has a fixed mapping to physical channel resources. However, it has been suggested that the mapping between the HS-DSCH and the physical resources (codes and carrier frequency) may be dynamically modified in order to provide a diversity benefit.

SUMMARY

[0005] A method and an apparatus for utilizing multiple carriers are disclosed. A WTRU capable of receiving on a single downlink carrier at a time may tune the receiver to one downlink carrier and switch the downlink carrier in accordance with a configured pattern. The WTRU may switch the carrier from an anchor carrier to a non-anchor carrier at a high speed shared control channel (HS-SCCH) sub-frame boundary, and switch back at an end of a subsequent high speed physical downlink shared channel (HS-PDSCH) subframe. The WTRU may switch the carrier at an HS-PDSCH sub-frame boundary. A WTRU capable of receiving on multiple downlink carriers simultaneously may tune the receiver to an anchor carrier and a supplementary carrier, and switch the supplemen-

tary carrier to another carrier based on a carrier switching order. The carrier switching order may be received via an HS-SCCH or via layer 2 signaling.

5 BRIEF DESCRIPTION OF THE DRAWINGS

[0006] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

10
 Figure 1 shows a medium access control (MAC) architecture for DC-HSDPA operations;
 Figure 2 shows a wireless communication system;
 Figure 3 is a functional block diagram of a WTRU and the Node-B of the wireless communication system of Figure 2;
 Figure 4 shows example carrier switch timing in accordance with one embodiment;
 Figure 5 shows example carrier switch timing in accordance with another embodiment;
 Figure 6 shows an example downlink carrier switching with two downlink carriers with one radio slot of guard intervals;
 Figure 7 shows an example fast dynamic carrier scheduling over the HS-SCCH in accordance with one embodiment; and
 Figure 8 shows an example of slower dynamic carrier scheduling using an HS-SCCH order.

30 DETAILED DESCRIPTION

[0007] When referred to hereafter, the terminology "WTRU" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, a machine-to machine (M2M) device, a sensor, or any other type of device capable of operating in a wireless environment. When referred to hereafter, the terminology "Node-B" includes but is not limited to a base station, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

[0008] The network may assign at least one downlink and/or at least one uplink carrier as an anchor downlink carrier and an anchor uplink carrier, respectively. For example, the anchor carrier may be defined as the carrier for carrying a specific set of control information for downlink/uplink transmissions. Any carrier that is not assigned as an anchor carrier is a supplementary carrier. Alternatively, the network may not assign an anchor carrier and no priority, preference, or default status may be given to any downlink or uplink carriers. For multi-carrier operation more than one supplementary carriers or supplementary carriers may exist.

[0009] Figure 2 shows a wireless communication system 100 including a plurality of WTRUs 110, a Node B 120, a controlling radio network controller (CRNC) 130, a serving radio network controller (SRNC) 140, and a

core network 150. The Node B 120 and the CRNC 130 may collectively be referred to as the universal terrestrial radio access network (UTRAN).

[0010] As shown in Figure 2, the WTRUs 110 are in communication with the Node B 120, which is in communication with the CRNC 130 and the SRNC 140. Although three WTRUs 110, one Node B 120, one CRNC 130, and one SRNC 140 are shown in Figure 2, it should be noted that any combination of wireless and wired devices may be included in the wireless communication system 100.

[0011] Figure 3 is a functional block diagram of a WTRU 110 and the Node B 120 of the wireless communication system 100 of Figure 2. As shown in Figure 3, the WTRU 110 is in communication with the Node B 120 and both are configured to perform a method of utilizing multiple carriers in high speed packet access system.

[0012] The WTRU 110 includes a processor 115, a receiver 116, a transmitter 117, a memory 118, and an antenna 119, and other components (not shown) that may be found in a typical WTRU. The memory 118 is provided to store software including operating system, application, etc. The processor 115 is provided to perform, alone or in association with the software, a method of utilizing multiple carriers in high speed packet access system in accordance with embodiments disclosed below. The receiver 116 may be capable of receiving via only one downlink carrier at a time or via multiple downlink carriers simultaneously. Alternatively, the WTRU 110 may include multiple receivers for reception via multiple downlink carriers simultaneously. The receiver 116 and the transmitter 117 are in communication with the processor 115. The antenna 119 is in communication with both the receiver 116 and the transmitter 117 to facilitate the transmission and reception of wireless data.

[0013] The Node B 120 includes a processor 125, a receiver 126, a transmitter 127, a memory 128, and an antenna 129, and other components (not shown) that may be found in a typical base station. The processor 125 is configured to support a method of utilizing multiple carriers in high speed packet access system in accordance with embodiments disclosed below. The receiver 126 and the transmitter 127 are in communication with the processor 125. The antenna 129 is in communication with both the receiver 126 and the transmitter 127 to facilitate the transmission and reception of wireless data.

[0014] Embodiments for multi-carrier operation with a receiver capable of operating with a single carrier at a time are explained hereafter. A WTRU is capable of receiving on a single downlink carrier at a given time. There may be a single HS-DSCH. The downlink carrier associated to this HS-DSCH may change dynamically on a subframe basis. The WTRU reads a subset of downlink control channels from one specific downlink carrier, (i.e., "anchor carrier"). This subset of control channels includes a fractional downlink physical channel (F-DPCH), an E-DCH absolute grant channel (E-AGCH), an E-DCH relative grant channel (E-RGCH), an E-DCH HARQ indicator channel (E-HICH). The other physical channels,

such as a common pilot channel (CPICH), a high-speed shared control channel (HS-SCCH) and a high-speed physical downlink shared channel (HS-PDSCH), may be transmitted on any downlink carrier.

5 [0015] In accordance with one embodiment, the change of downlink carrier may follow a pre-determined pattern or a pattern signaled from a higher layer. For example, each downlink carrier may be used every other subframe, or each downlink carrier may be used in alternation for two consecutive subframes. Such change of downlink carrier allows the network (Node-B) scheduler to schedule HARQ retransmissions in a downlink carrier different from the one used for the initial HARQ transmission, thus providing a frequency diversity gain. It is not required that all downlink carriers be used equally frequently.

10 [0016] There are different possibilities for the exact time that the downlink carrier is switched. Since all the downlink control channels may not be synchronized on a subframe basis, the information from some control channels of the anchor carrier may be lost for certain subframes since a fraction of the sub-frame can be listened to, unless the Node-B switches the downlink carrier for these channels as well.

15 [0017] In accordance with one embodiment, the WTRU may switch its downlink carrier from the anchor carrier to the non-anchor carrier (i.e., supplementary carrier) at the HS-SCCH sub-frame boundary and switch back at the end of a subsequent HS-PDSCH subframe.

20 Figure 4 shows example carrier switch timing in accordance with this embodiment. In this case, the WTRU misses the last E-AGCH, E-RGCH, and E-HICH subframe that start before the switch to the non-anchor carrier and all subsequent E-AGCH, E-RGCH, and E-HICH subframes up to and including the subframe that start before the end of the last HS-PDSCH subframe on the non-anchor carrier. In addition, the last HS-SCCH subframe on the non-anchor carrier that starts before the end of the last HS-PDSCH subframe is also lost.

25 [0018] In accordance with another embodiment, the WTRU may switch its downlink carrier at the HS-PDSCH sub-frame boundary. Figure 5 shows example carrier switch timing in accordance with this alternative embodiment. Given the two-slots offset between the HS-SCCH

30 sub-frame and its corresponding HS-PDSCH sub-frame, the Node-B may transmit the first two slots of the HS-SCCH subframe on the pre-switch carrier and transmit the last slot of the HS-SCCH subframe on the post-switch carrier. One advantage of this embodiment is that the WTRU does not miss an HS-DSCH sub-frame when it switches from one carrier to another. In addition, since the E-AGCH subframe boundary is synchronized with the HS-PDSCH subframe boundary, loss of E-AGCH subframes is minimized.

35 [0019] Alternatively, a guard interval may be included before every carrier switching. This guard interval may be necessary to allow the receiver to tune and synchronize to the newly selected downlink carrier. During this

guard interval, the WTRU may not receive any control or data messages from any Node-B. Figure 6 shows an example downlink carrier switching with two downlink carriers with one radio slot of guard intervals and a carrier switching cycle of 6 TTIs.

[0020] This guard interval may be predefined. This guard interval may have a duration of one radio slot to maintain the existing timing among data and control channels. Alternatively, the network may configure the WTRU with a specific guard interval, which may be cell-specific.

[0021] The timing or behavior of the various downlink control channels needs to be modified to take into consideration the guard intervals. In particular, the E-HICH has a strict timing to comply to. When the E-HICH is transmitted during a guard interval, the WTRU misses that interval from the transmitted signal. In order to mitigate the impact of this missing radio slot, the network may transmit the E-HICH with a higher power when the network knows that the E-HICH transmission will fall during a guard interval (similar to the compress mode gaps in the uplink). Alternatively, the WTRU may not expect an E-HICH during the guard interval and interprets the missing E-HICH as a negative acknowledgement (NACK) and therefore systematically performs a HARQ retransmission. Optionally, the additional HARQ retransmission may be performed regardless of the maximum number of HARQ retransmissions allowed for that HARQ process. Alternatively, the WTRU may not transmit in a HARQ process that is known to have its corresponding E-HICH fall during a guard interval.

[0022] Since there is one HS-DSCH transmission for a given sub-frame, there is no ambiguity with the HARQ positive acknowledgement (ACK)/negative acknowledgement (NACK) transmission, and the timing and format of the HARQ ACK/NACK information may take place as in the conventional procedure.

[0023] The WTRU needs to report a channel quality indicator (CQI) of all downlink carriers. The WTRU may report the CQI for one downlink carrier in each HS-DPCCH subframe. The downlink carrier for which the CQI is reported is the carrier that the WTRU is receiving on according to the pattern for an HS-PDSCH subframe that is received X ms later or earlier. The WTRU evaluates the CQI by measuring the CPICH during the subframe received X ms earlier on the corresponding carrier.

[0024] Alternatively, the WTRU may report the CQI for more than one carrier in each HS-DPCCH subframe. For instance, if there are two downlink carriers (including the anchor carrier) the WTRU may report two CQIs.

[0025] The WTRU may in principle transmit continuously on the uplink since the uplink carrier is not switched. However, the downlink control channels required to control the uplink transmissions, (e.g., F-DPCH, E-AGCH, E-HICH, E-RGCH, etc.), that are transmitted on the anchor carrier may not be available for all subframes since the WTRU may be receiving sometimes on a non-anchor carrier. The WTRU may not transmit an E-DCH during

subframes for which the corresponding E-AGCH, E-RGCH, or E-HICH subframes (as per the conventional timing relationship) are not received. Alternatively, the WTRU may be allowed to transmit non-scheduled transmissions on an E-DCH during subframes for which the corresponding E-AGCH subframes are not received.

5 In a case where the E-HICH subframe is not received, the WTRU may be allowed to retransmit a MAC-e or MAC-i protocol data unit (PDU) as if a HARQ NACK had been transmitted over the E-HICH. Alternatively, the WTRU 10 may be allowed to transmit the DPCCH, HS-DPCCH, E-DPCCH or E-DPDCH if the F-DPCH was received a certain number of slots earlier.

[0026] With respect to MAC architecture, eight (or in 15 general N, N being an integer) HARQ processes may be configured that may be used across all downlink carriers. This would allow HARQ retransmissions on different carriers and simplify signaling mechanisms.

[0027] Embodiments for multi-carrier operation with a 20 receiver capable of operating with two carriers simultaneously are explained hereafter. The embodiments equivalently apply to a WTRU equipped with two receivers operating simultaneously, each being capable of receiving on a single carrier. It should be noted that the 25 embodiments are also applicable to WTRUs with a receiver having a capability of processing on more than two carriers simultaneously, or a WTRU with multiple receivers for receiving multiple carriers. The following embodiments may apply to an evolved HSPA system and 30 WTRU. They may also apply to a LTE-advanced (LTE-A) system and WTRU. In the case of an LTE or LTE-A system, the downlink control channels physical downlink control channel (PDCCH) and physical HARQ indicator channel (PHICH) together may be used in place of a set 35 of F-DPCH, E-AGCH, E-RGCH and E-HICH. In addition, in an LTE or LTE-A system, the physical channels PDCCH and physical downlink shared channel (PDSCH) may be used in place of the HS-SCCH and HS-PDSCH, respectively. In addition, in an LTE or LTE-A system, a 40 cell radio network temporary identity (C-RNTI) may be used in place of the H-RNTI or E-RNTI.

[0028] A subset of downlink control channels, (e.g., F-DPCH, E-AGCH, E-RGCH, E-HICH), may be received 45 on the anchor carrier. Other downlink control or data physical channels, such as HS-SCCH and/or HS-PDSCH, may be received from any downlink carrier. The receiver of the WTRU is tuned to the anchor carrier to ensure proper reception of the control channels. The receiver may also be tuned to any other downlink carrier 50 at any given time in order to receive downlink traffic over the HS-DSCH. Alternatively, the receiver may be tuned to any two or more carriers.

[0029] The WTRU monitors the F-DPCH, E-AGCH, E-RGCH, and E-HICH from the anchor carrier. The WTRU monitors the HS-SCCH and HS-PDSCH on more than 55 one (Nc) downlink carriers according to the mapping between the Nc HS-DSCH transport channels and the downlink carriers.

[0030] Upon radio resource control (RRC) connection setup or upon transitioning to the CELL_DCH state, the network configures the WTRU with the Nc downlink carrier information. More specifically, the network may configure, but is not limited to, the CPICH information, HS-DSCH radio network temporary identity (H-RNTI), HS-SCCH frequency information, and other parameters that may be required. The H-RNTI and HS-SCCH may not need to be configured for all carriers. A different set of parameters may be configured for LTE, LTE-A, or other types of systems.

[0031] The change of downlink carrier may follow a pre-determined pattern or a pattern signaled from a higher layer. There may be at least one HS-DSCH mapped to the anchor carrier at a given time. This allows for continuous reception of the F-DPCH, E-AGCH, E-RGCH and E-HICH and thus allows for continuous transmission on the uplink.

[0032] In accordance with another embodiment, the WTRU may perform a fast and dynamic downlink carrier switching under the control of the Node B. The scheduling of the WTRU may be signaled to the WTRU, for example, via an HS-SCCH on the anchor carrier. The WTRU may monitor one HS-SCCH on the anchor carrier to obtain the information required to decode the data (such as the code set, the modulation format, the HARQ process, redundancy version (RV), etc. and the carrier in which the data is being scheduled). In case of an LTE system, the information required to decode the data may include information pertaining to the allocated sub-carriers as per the used downlink control information (DCI) format of the PDCCH. This removes the requirement from the WTRU to monitor the HS-SCCH of different carriers. The WTRU may monitor the HS-SCCH on the anchor carrier and move directly to the HS-PDSCH of the indicated downlink carrier. In the LTE case, the WTRU may monitor the PDCCH on the anchor carrier and move directly to the PDSCH of the indicated downlink carrier.

[0033] In order to signal the carrier information, an additional bit(s) may be included in the HS-SCCH to explicitly indicate the carrier number (i.e., an index to the downlink carrier). Alternatively, the carrier information may be implicitly indicated, for example via the use of different H-RNTI. More specifically, the network may configure a different H-RNTI for each downlink carrier. Upon decoding the H-RNTI in the HS-SCCH, the WTRU determines the downlink carrier associated with the decoded H-RNTI in which to monitor the HS-PDSCH. Alternatively, the carrier information may be indicated by the HS-SCCH code number such that a different channelization code may implicitly indicate the downlink carrier number. Alternatively, the carrier information may be indicated by the HARQ process number. HARQ processes may be allocated per downlink carrier and depending on the HARQ process signaled on the HS-SCCH the WTRU may detect which downlink carrier it corresponds to.

[0034] Since the time to switch the receiver from one frequency to another may not be instantaneous, for cor-

rect reception of data, the HS-SCCH may indicate the information X TTIs or slots in advance, where X may be equal to 0 (i.e., same timing as for current systems is maintained) or any arbitrary value predefined or signaled by the network. Figure 7 shows an example fast dynamic carrier scheduling over the HS-SCCH in accordance with this embodiment, where X is set to zero. If a different timing requirement is set, the WTRU may start monitoring the HS-PDSCH X slots or TTI after the reception of the HS-SCCH. In case of an LTE system, the WTRU may start monitoring the PDSCH X slots or TTIs after the reception of the PDCCH.

[0035] In Figure 7, the downlink carrier scheduling information is indicated via the HS-SCCH on the anchor carrier. The WTRU receives the HS-SCCH on the anchor carrier and switches the other carrier to receive the HS-PDSCH in accordance with the scheduling information received via the HS-SCCH.

[0036] In the case where the WTRU may switch directly to the new carrier, (i.e., X = 0), for explicit signaling the HS-SCCH Part 1 needs to contain the carrier information. This would allow the WTRU to know what downlink carrier to start monitoring the applicable HS-PDSCH codes. If X TTI or slot delay (X ≥ 1) is applied to monitor the HS-PDSCH, the carrier information may be contained in Part 2 as well. This would allow the WTRU to fully decode the three time slots of the HS-SCCH.

[0037] For this embodiment, since the WTRU is monitoring the anchor carrier, the network may schedule the WTRU on the HS-PDSCH of the anchor carrier and additionally on the HS-PDSCH of other carrier(s). This may be done with the use of two H-RNTIs, one H-RNTI for the anchor carrier and the other H-RNTI for other carriers. Alternatively, two sets of HS-SCCH codes may be used, or two sets of HARQ processes may be configured. For instance, the first eight HARQ processes may be used for the anchor carrier, and the other set of HARQ processes may be shared among other carriers. Explicit carrier signaling may also be used, and the network may schedule the WTRU on two downlink carriers in the same TTI using two different HS-SCCH codes.

[0038] In accordance with another embodiment, the WTRU may perform slower dynamic switching under the control of the Node-B. The slower dynamic switching may be controlled by L1 or L2 signaling in the anchor cell or alternatively in any of the other cells the WTRU is monitoring.

[0039] An HS-SCCH order may be used to indicate the downlink carrier the WTRU should switch to. The HS-SCCH order may include an order bit(s) for carrier switching and an information bit(s) to indicate the downlink carrier number the WTRU should start monitoring. Upon reception of the HS-SCCH order the WTRU switches to the indicated downlink carrier, X slots or TTIs after the reception of the HS-SCCH order, where X may be 0 or any other predefined or configured value (e.g., 12 slots) and monitoring the HS-SCCH on the indicated downlink carrier. The WTRU may continue to monitor the HS-

SCCH and the HS-PDSCH on the carrier until another order is received on the anchor carrier or on the supplementary carrier. Figure 8 shows an example of slower dynamic carrier scheduling using an HS-SCCH order, where the HS-SCCH orders are provided in the anchor carrier and X is equal to 0. In Figure 8, the WTRU switches the supplementary carrier to carrier 2 (C2) to carrier n (Cn) to carrier 3 (C3) as the HS-SCCH order on the anchor carrier indicates.

[0040] Alternatively, the HS-SCCH order for carrier change may be provided in the supplementary carrier. In that case, for example, the WTRU receives an HS-SCCH order for carrier switch on carrier 2 and switches to carrier n after X slots or TTIs, and receives an HS-SCCH order for carrier switch on carrier n and moves to carrier 3 after X slots or TTIs.

[0041] For this embodiment, the network may configure the WTRU with an H-RNTI for each carrier. When the WTRU moves to the indicated carrier it monitors the HS-SCCH for the corresponding H-RNTI. Alternatively, an H-RNTI that is common to all supplementary carriers may be assigned.

[0042] Instead of an HS-SCCH order, an L2 message may be used, (e.g., MAC-hs/ehs PDU). The carrier indication may be included in the payload of the MAC PDU or in the header part, (e.g., may be indicated by a special value of the logical channel identity (LCH-ID)).

[0043] In case where the number of downlink carriers is more than two, the receiver of the WTRU may be tuned to the anchor carrier and one (or more) of the supplementary carriers, while the supplementary carrier to be tuned is dynamically switched from one supplementary carrier to another. Alternatively, the receiver may be tuned to any two (or more) downlink carriers. The switching time for the receiver may follow one of the embodiments disclosed above; (e.g., embodiments related to Figures 4-6).

[0044] The ACK/NACK feedback for the supplementary carrier may be provided as in the conventional HSDPA procedures. Since the WTRU is monitoring one of the supplementary carriers at a time there is no ambiguity in the ACK/NACK feedback. Since the WTRU is monitoring the anchor carrier the CQI reporting for the anchor carrier may follow the conventional HSDPA procedure. However, in order to report the CQI of the supplementary carriers the WTRU may follow the following rules. Each carrier may have a corresponding subframe number during which the WTRU is allowed to measure and report the CQI. The network knows the mapping, (i.e., the configured subframes for each downlink carrier), and thus knows for which downlink carrier the CQI is being reported on the feedback channel. Alternatively, a strict timing between the downlink carrier in which data is received and the reporting may be defined. Alternatively, the CQI format in the HS-DPCCH may be modified to explicitly indicate the carrier number.

[0045] Since the WTRU may not be monitoring all the downlink carriers it may not be able to measure and pro-

vide CQI reports for all downlink carriers. The CQI reporting is a useful measure to help the scheduler in the network. The WTRU may be configured to measure and report when receiving data from a carrier. Alternatively, the WTRU may be configured with a measurement period to tune to each carrier and perform measurements. The pattern may be defined by the network or the measurement may be performed in accordance with a predefined formula, for example, based on the H-RNTI. The receiver may perform the measurement only on the supplementary carrier. If discontinuous reception (DRX) is configured the WTRU may use the DRX periods to take measurements.

5 **15** Embodiments

[0046]

10 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 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2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 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bodiments wherein information from some channels of the anchor carrier is lost for certain subframes because only a fraction of the subframes may be listened to unless a base station also switches the carrier frequency for these channels. 5

10. The method as in any one of the preceding embodiments wherein the carrier switch to a non-anchor carrier occurs at the HS-SCCH subframe boundary and switches back at the end of a subsequent HS-PDSCH subframe. 10

11. The method as in any one of the preceding embodiments wherein the carrier switch occurs at the HS-PDSCH subframe boundary. 15

12. The method of embodiment 11 wherein the HS-SCCH is received on the pre-switch carrier for the two first slots of the HS-SCCH subframe and the last slot of the HS-SCCH is received on the post-switch carrier provided there is a two-slots offset between a HS-SCCH subframe and its corresponding HS-PDSCH subframe. 20

13. The method as in any one of the preceding embodiments wherein a guard interval is included before each carrier switching event. 25

14. The method as in any one of the preceding embodiments wherein the guard interval allows the single carrier to tune and synchronize to a newly selected carrier. 30

15. The method as in any one of the preceding embodiments wherein no control or data messages from a base station are received during the guard interval. 35

16. The method as in any one of the preceding claims wherein the guard interval has a duration of one radio slot. 40

17. The method as in any one of the preceding embodiments wherein the WTRU is configured with a specific guard interval that is cell-specific. 45

18. The method as in any one of the preceding embodiments wherein the timing or behavior of the downlink control channels are modified to account for the guard intervals. 50

19. The method of embodiment 18 wherein the timing or behavior of the E-HICH is modified because it has a strict timing requirement. 55

20. The method as in any one of embodiments 18-19 wherein the E-HICH is transmitted by the base station with higher power when the base station is aware that it will fall during a guard period.

21. The method as in any one of embodiments 18-20 wherein the WTRU interprets the missing E-HICH as a NACK because the WTRU knows not to expect an E-HICH during the guard interval and the WTRU performs a HARQ retransmission.

22. The method of embodiment 21 wherein the additional HARQ retransmission is performed regardless of the maximum number of HARQ retransmissions allowed for that HARQ process.

23. The method as in any one of embodiments 18-20 wherein the WTRU does not transmit in a HARQ process that is known to have its corresponding E-HICH fall during a guard interval.

24. The method as in any one of the preceding embodiments further comprising reporting the channel quality indicator (CQI) of all carriers.

25. The method of embodiment 24 wherein the CQI is reported for one carrier in each HS-DPCCH subframe.

26. The method as in any one of embodiments 24-25 wherein the carrier for which the CQI is reported is the carrier that the WTRU is receiving on according to the pattern for a HS-PDSCH subframe that is received a number of milliseconds later or earlier.

27. The method as in any one of the preceding embodiments wherein the CQI is evaluated by measuring the CPICH during a subframe received a number of milliseconds earlier on a corresponding carrier.

28. The method as in any one of the preceding embodiments wherein the CQI is reported for more than one carrier in each HS-DPCCH subframe.

29. The method as in any one of the preceding embodiments wherein the WTRU does not transmit using the E-DCH during subframes for which the corresponding E-AGCH, E-RGCH, or E-HICH subframes are not received.

30. The method as in any one of the preceding embodiments wherein the WTRU transmits non-scheduled transmissions on the E-DCH during subframes for which the corresponding E-AGCH subframes are not received.

31. The method of embodiment 30 wherein the WTRU retransmits a MAC-e or MAC-i PDU as if a HARQ NACK had been transmitted over E-HICH when the E-HICH subframe is not received.

32. The method as in any one of the preceding embodiments wherein the WTRU transmits the DPCCH, HS-DPCCH, E-DPCCH or E-DPDCH if the F-DPCH was received a certain number of slots earlier.

33. The method as in any one of the preceding embodiments wherein a MAC layer architecture is configured such that eight HARQ processes may be used across all carriers and HARQ retransmissions are allowed on different carriers.

34. A method for use in a wireless transmit/receive unit (WTRU) for using multiple carriers with a dual radio in a high speed packet access (HSPA) system, the method comprising:

receiving more than one HS-DSCH transport channel, wherein a carrier associated with the HS-DSCH transport channel is changed dynamically on a subframe basis; and processing a subset of downlink control channels from an anchor carrier.

35. The method of embodiment 34 wherein the subset of downlink control channels controls uplink transmissions. 5

36. The method as in any one of embodiments 34-35 wherein the subset of downlink control channels includes the fractional downlink physical channel (F-DPCH), the enhanced absolute grant channel (E-AGCH), the enhanced relative grant channel (E-RGCH), and the enhanced HARQ indicator channel (E-HICH). 10

37. The method as in any one of embodiments 34-36 further comprising constantly monitoring the F-DPCH, E-AGCH, E-RGCH, E-HICH from the anchor carrier. 15

38. The method as in any one of embodiments 34-37 further comprising monitoring the HS-SCCH and HS-PDSCH on more than one (Nc) carriers, according to a mapping between the Nc HS-DSCH transport channels and the frequencies of the carriers. 20

39. The method as in any one of embodiments 34-38 wherein the anchor carrier is the carrier frequency in which all downlink (DL) control channels are transmitted. 25

40. The method as in any one of embodiments 34-39 wherein one of the receivers in the WTRU is always tuned to the anchor carrier frequency to ensure the proper reception of the control channels. 30

41. The method as in any one of embodiments 34-40 wherein one of the receivers in the WTRU is tuned to any other carrier frequency at any given time in order to receive DL traffic over the HS-DSCH transport channel. 35

42. The method as in any one of embodiments 34-41 further comprising receiving Nc carrier information from a base station, wherein the received information is used to configure at least the CPICH information, H-RNTI, HS-SCCH, frequency information, and/or any other required parameter. 40

43. The method of embodiment 42 wherein the Nc carrier information is received upon the setup of the radio resource control (RRC) connection or upon the transition of the WTRU to the CELL_DCH state. 45

44. The method as in any one of embodiments 34-43 further comprising performing a carrier change. 50

45. The method as in any one of embodiments 34-44 wherein the carrier change follows a predetermined pattern or a pattern signaled from higher layers. 55

46. The method as in any one of embodiments 34-45 wherein there is at least one HS-DSCH mapped to the carrier frequency of the anchor carrier.

47. The method as in any one of embodiments 34-46 wherein the scheduling of a carrier switch is controlled by the base station.

48. The method of embodiment 47 wherein the scheduling of the WTRU is controlled and signaled to the WTRU using the HS-SCCH of the anchor cell. 55

49. The method as in any one of embodiments 47-48 wherein the HS-SCCH includes additional bits to explicitly indicate the carrier number and provide an index to the carrier.

50. The method as in any one of embodiments 47-49 wherein the WTRU receives carrier information that is signaled implicitly using different H-RNTI and determines the carrier in which to monitor the HS-PDSCH.

51. The method as in any one of embodiments 47-50 wherein the WTRU receives carrier information using the HS-SCCH code number.

52. The method as in any one of embodiments 47-51 wherein the WTRU receives carrier information using a HARQ process number, the HARQ processes being allocated per carrier and depending on the HARQ process signaled on the HS-SCCH.

53. The method as in any one of embodiments 47-52 wherein the WTRU monitors the HS-SCCH in the anchor cell and moves directly to the HS-PDSCH of the indicated carrier.

54. The method as in any one of embodiments 34-53 wherein the HS-SCCH indicates the information x TTIs or slots in advance in order to guarantee correct reception of data, where x may be equal to zero or any arbitrary value predefined or signaled by the network.

55. The method as in any one of embodiments 34-54 wherein the WTRU monitors the HS-PDSCH on carrier Nc x slots or TTI after reception of the HS-SCCH if the network sets a different timing requirement.

56. The method of embodiment 55 wherein the HS-SCCH Part 1 contains the carrier information for explicit signaling when the WTRU is able to switch directly to the new carrier.

57. The method as in any one of embodiments 55-56 wherein the HS-SCCH Part 2 contains the carrier information for explicit signaling when there is a delay applied for the WTRU to monitor the applicable HS-PDSCH codes.

58. The method according to any one of embodiments 34-57 wherein the WTRU is scheduled on the HS-PDSCH of the anchor cell and on the HS-PDSCH of any of the other carrier.

59. The method of embodiment 58 wherein the WTRU is scheduled using two H-RNTIs, where one H-RNTI is used for the anchor cell and the another H-RNTI is used for the other carriers.

60. The method of embodiment 58 wherein the WTRU is scheduled using two sets of HS-SCCH codes.

61. The method of embodiment 58 wherein the WTRU is scheduled using two sets of HARQ processes.

62. The method of embodiment 58 wherein the WTRU is scheduled on two carriers in the same TTI using two different HS-SCCH codes when explicit carrier signaling is used.

63. The method according to any one of embodiments 34-62 further comprising performing a slower

dynamic switching as controlled by the base station.

64. The method of embodiment 63 wherein the base station controls the slower switching using L1 or L2 signaling in the anchor cell. 5

65. The method of embodiment 63 wherein the base station controls the slower switching in any of the other cells that the WTRU is monitoring.

66. The method according to any one of embodiments 63-65 wherein an HS-SCCH order is used by the base station to indicate the carrier to which the WTRU should be switched. 10

67. The method according to any one of embodiments 34-66 further comprising receiving a carrier switch order, wherein the carrier switch order and other information bits are used to indicate the carrier number the WTRU should start monitoring with an available receiver. 15

68. The method according to any one of embodiments 34-67 further comprising switching to the indicated carrier, x slots or TTIs after the reception of the order, where x can be 0 or any other predefined or configured value. 20

69. The method according to any one of embodiments 34-68 further comprising monitoring the HS-SCCH of the indicated carrier (Nc) for data information. 25

70. The method according to any one of embodiments 34-69 further comprising monitoring the HS-SCCH and HS-PDSCH of carrier Nc, until another order is received on the anchor cell or the supplementary cell.

71. The method according to any one of embodiments 34-70 wherein an HS-SCCH order is used to indicate a carrier change, the HS-SCCH order being provided in the supplementary cells.

72. The method according to any one of embodiments 34-71 wherein the WTRU is configured with an H-RNTI for each carrier.

73. The method according to any one of embodiments 34-72 wherein the WTRU monitors the HS-SCCH for the corresponding H-RNTI when the WTRU moves to an indicated carrier.

74. The method according to any one of embodiments 34-73 wherein a common H-RNTI is assigned to all supplementary carriers.

75. The method according to any one of embodiments 34-74 wherein a L2 message is used by the base station to indicate a carrier change.

76. The method according to any one of embodiments 34-75 wherein one of the two radios is permanently tuned to the anchor carrier and second radio is dynamically tuned from one supplementary carrier to another. 50

77. The method according to any one of embodiments 34-76 wherein each carrier has a corresponding subframe number during which the WTRU is allowed to measure and report the CQI and the network is aware for which carrier the CQI is being re- 55

ported on the feedback channel.

78. The method according to any one of embodiments 34-77 wherein a strict timing between the carrier in which data is received and the reporting is defined.

79. The method according to any one of embodiments 34-78 wherein the CQI format in the HS-DPCCH is modified to explicitly indicate the carrier number.

80. The method according to any one of embodiments 34-79 wherein the WTRU measures and reports the CQI when receiving data from a carrier.

81. A wireless transmit/receive unit (WTRU) configured to perform the method as in any one of embodiments 1-80.

82. An integrated circuit configured to perform the method as in any one of embodiments 1-80.

83. A base station configured to perform the method as in any one of embodiments 1-80.

[0047] Although features and elements are described above in particular combinations, each feature or element may be used alone without the other features and elements or in various combinations with or without other features and elements. The methods or flow charts provided herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). **[0048]** Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine. **[0049]** A processor in association with software may be used to implement a radio frequency transceiver for use in a wireless transmit receive unit (WTRU), user equipment (UE), terminal, base station, radio network controller (RNC), or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet

browser, and/or any wireless local area network (WLAN) or Ultra Wide Band (UWB) module.

Itemized list of embodiments

[0050]

1. A method, implemented in a wireless transmit/receive unit (WTRU) with a receiver capable of receiving on one downlink carrier at a time, for utilizing multiple carriers, the method comprising:
the WTRU tuning a receiver to one downlink carrier; and
the WTRU switching a downlink carrier in accordance with a configured pattern. 10

2. The method of item 1 wherein the WTRU switches the downlink carrier from an anchor carrier to a non-anchor carrier at a high speed shared control channel (HS-SCCH) sub-frame boundary, and switches from the non-anchor carrier to the anchor carrier at an end of a subsequent high speed physical downlink shared channel (HS-PDSCH) subframe. 20

3. The method of item 1 wherein the WTRU switches the downlink carrier at a high speed physical downlink shared channel (HS-PDSCH) sub-frame boundary. 25

4. The method of item 1 wherein the WTRU switches the downlink carrier after a guard interval.

5. The method of item 4 wherein the WTRU interprets a missing E-DCH HARQ indicator channel (E-HICH) during the guard interval as a negative acknowledgement (NACK). 35

6. The method of item 4 wherein the WTRU does not transmit in a hybrid automatic repeat request (HARQ) process that has its corresponding E-DCH HARQ indicator channel (E-HICH) falling during the guard interval. 40

7. A method, implemented in a wireless transmit/receive unit (WTRU) capable of receiving on multiple downlink carriers simultaneously, for utilizing multiple carriers, the method comprising:
the WTRU tuning a receiver to an anchor carrier and a supplementary carrier; 50
the WTRU receiving a carrier switching order; and
the WTRU switching the supplementary carrier to another downlink carrier based on the carrier switching order. 55

8. The method of item 7 wherein the WTRU receives

the carrier switching order via a high speed shared control channel (HS-SCCH) or via layer 2 signaling.

9. The method of item 8 wherein the WTRU determines a downlink carrier to which the WTRU is required to tune the receiver based on a specific bit in the HS-SCCH.

10. The method of item 8 wherein the WTRU determines a downlink carrier to which the WTRU is required to tune the receiver based on at least one of an HS-DSCH radio network temporary identity (H-RNTI) decoded in the HS-SCCH, a high speed shared control channel (HS-SCCH) channelization code used for the HS-SCCH, or a hybrid automatic repeat request (HARQ) process number used for the HS-SCCH.

11. The method of item 7 further comprising:
the WTRU reporting a channel quality indicator (CQI) for the downlink carriers.

12. The method of item 11 wherein the WTRU measures the CQI for a configured subframe for each downlink carrier.

13. The method of item 11 wherein the WTRU reports the CQI for the downlink carriers in accordance with a strict timing relationship between the downlink carriers and an uplink transmission for the reporting.

14. A wireless transmit/receive unit (WTRU) for utilizing multiple carriers, the WTRU comprising:
a receiver configured to receive on one downlink carrier at a time; and
a processor configured to control the receiver to switch a downlink carrier in accordance with a configured pattern.

15. The WTRU of item 14 wherein the processor is configured to switch the downlink carrier from an anchor carrier to a non-anchor carrier at a high speed shared control channel (HS-SCCH) sub-frame boundary, and switch from the non-anchor carrier to the anchor carrier at an end of a subsequent high speed physical downlink shared channel (HS-PDSCH) subframe.

16. The WTRU of item 14 wherein the processor is configured to switch the downlink carrier at a high speed physical downlink shared channel (HS-PDSCH) sub-frame boundary.

17. The WTRU of item 14 wherein the processor is configured to switch the downlink carrier after a guard interval.

18. The WTRU of item 17 wherein the processor is configured to interpret a missing E-DCH HARQ indicator channel (E-HICH) during the guard interval as a negative acknowledgement (NACK).

19. The WTRU of item 17 wherein the processor is configured to not transmit in a hybrid automatic repeat request (HARQ) process that has its corresponding E-DCH HARQ indicator channel (E-HICH) falling during the guard interval.

20. A wireless transmit/receive unit (WTRU) for utilizing multiple carriers, the WTRU comprising:

at least one receiver for receiving on multiple downlink carriers simultaneously including an anchor carrier and a supplementary carrier; and a processor configured to receive a carrier switching order and switch the supplementary carrier to another downlink carrier based on the carrier switching order.

21. The WTRU of item 20 wherein the carrier switching order is received via a high speed shared control channel (HS-SCCH) or via layer 2 signaling.

22. The WTRU of item 21 wherein the processor is configured to determine a downlink carrier to which the WTRU is required to tune the receiver based on a specific bit in the HS-SCCH.

23. The WTRU of item 21 wherein the processor is configured to determine a downlink carrier to which the WTRU is required to tune the receiver based on at least one of an HS-DSCH radio network temporary identity (H-RNTI) decoded in the HS-SCCH, a high speed shared control channel (HS-SCCH) channelization code used for the HS-SCCH, or a hybrid automatic repeat request (HARQ) process number used for the HS-SCCH.

24. The WTRU of item 20 wherein the processor is configured to report a channel quality indicator (CQI) for the downlink carriers.

25. The WTRU of item 24 wherein the processor is configured to measure the CQI for a configured subframe for each downlink carrier.

26. The WTRU of item 24 wherein the processor is configured to report the CQI for the downlink carriers in accordance with a strict timing relationship between the downlink carriers and an uplink transmission for the reporting.

Claims

1. A method, implemented in a wireless transmit/receive unit, WTRU, the method comprising:

monitoring for scheduling information on a control channel associated with a first frequency; receiving the scheduling information on the control channel associated with the first frequency, the scheduling information indicating that data is to be received on a shared channel associated with a second frequency; switching from the first frequency to the second frequency during a switching time, the switching time signaled by the network; receiving the data on the shared channel associated with the second frequency; switching from the second frequency to the first frequency; and monitoring the control channel associated with the first frequency.

2. A wireless transmit/receive unit, WTRU, for utilizing multiple carriers, the WTRU comprising:

a processor configured to:

monitor for scheduling information on a control channel associated with a first frequency; receive the scheduling information on the control channel associated with the first frequency, the scheduling information indicating that data is to be received on a shared channel associated with a second frequency; switch from the first frequency to the second frequency during a switching time, the switching time signaled by the network; receive the data on the shared channel associated with the second frequency; switch from the second frequency to the first frequency; and monitor the control channel associated with the first frequency.

3. The method of claim 1 or the WTRU of claim 2, wherein the control channel is a Physical Downlink Control Channel, PDCCH, and the shared channel is a Physical Downlink Shared Channel, PDSCH.

4. The method of claim 3 or the WTRU of claim 3, wherein the scheduling information is downlink control information, DCI.

5. The method of claim 1 or the WTRU of claim 2, wherein the scheduling information indicates an index associated with a second frequency.

6. The method of claim 1 or the WTRU of claim 2, wherein the switching time is X time slots after the

reception of the scheduling information, where X is
> 0.

7. The method of claim 6 or the WTRU of claim 6,
wherein the scheduling information indicates a value 5
for X.
8. The method of claim 1, wherein switching from the
first frequency to the second frequency during the
switching time comprises tuning a receiver of the 10
WTRU to the second frequency during the switching
time.
9. The method of claim 1, wherein monitoring for the
scheduling information on the control channel asso- 15
ciated with the first frequency is performed by a re-
ceiver of the WTRU that is configured to receive over
a single frequency at a time.
10. The WTRU of claim 2, further comprising a receiver 20
configured to receive over a single frequency at a
time.
11. The WTRU of claim 2, further comprising a receiver
configured to tune from the first frequency to the sec- 25
ond frequency during the switching time.

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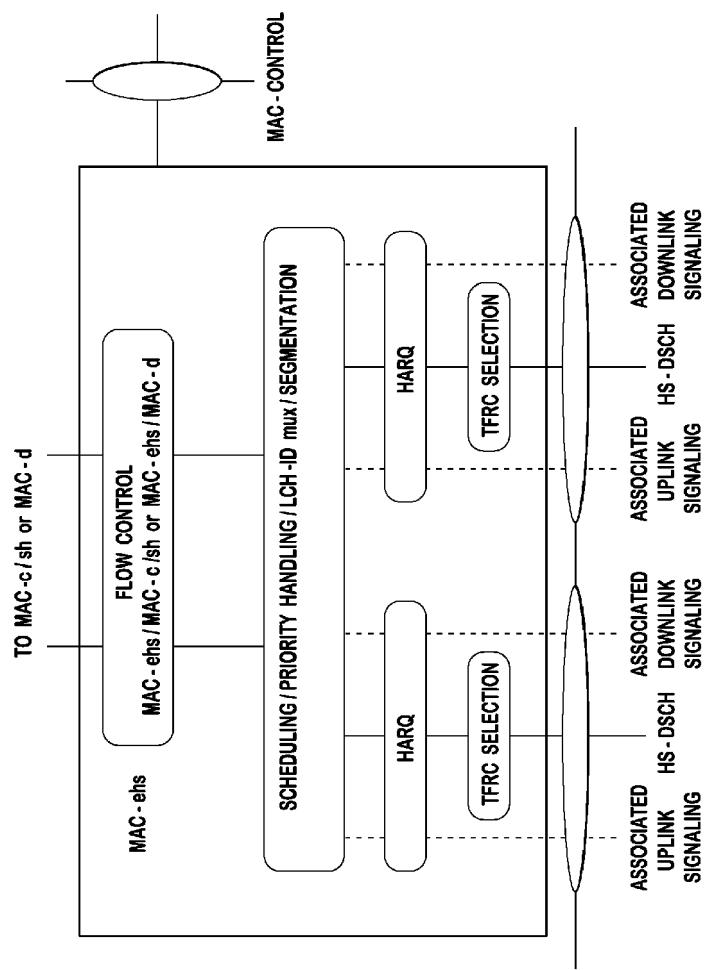


FIG. 1
(PRIOR ART)

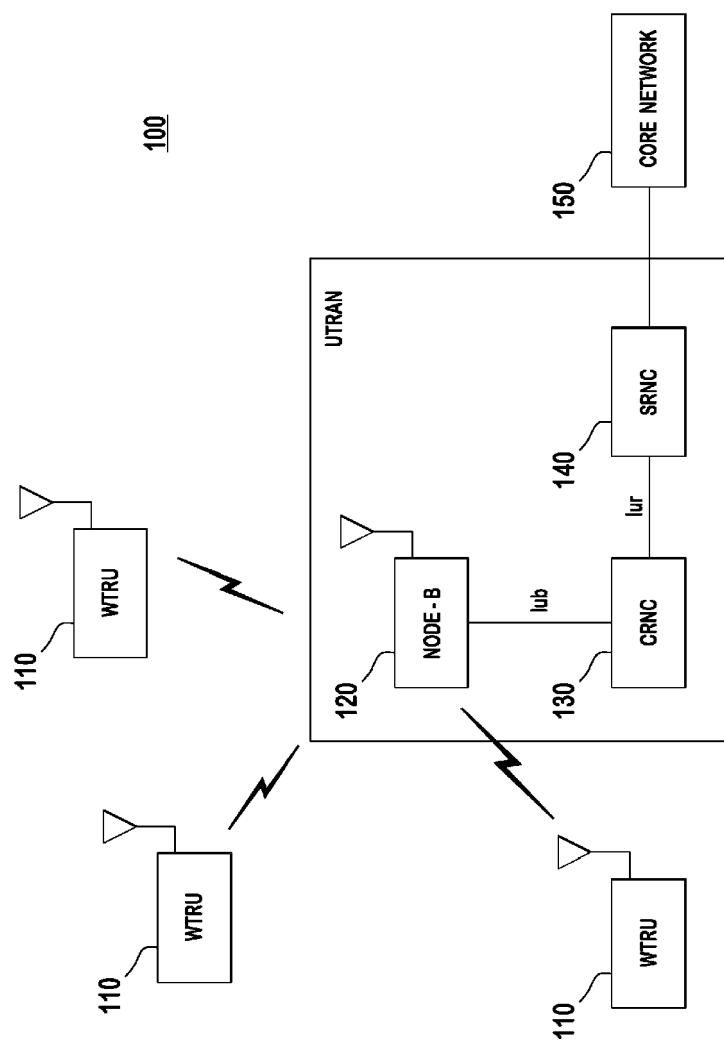


FIG. 2

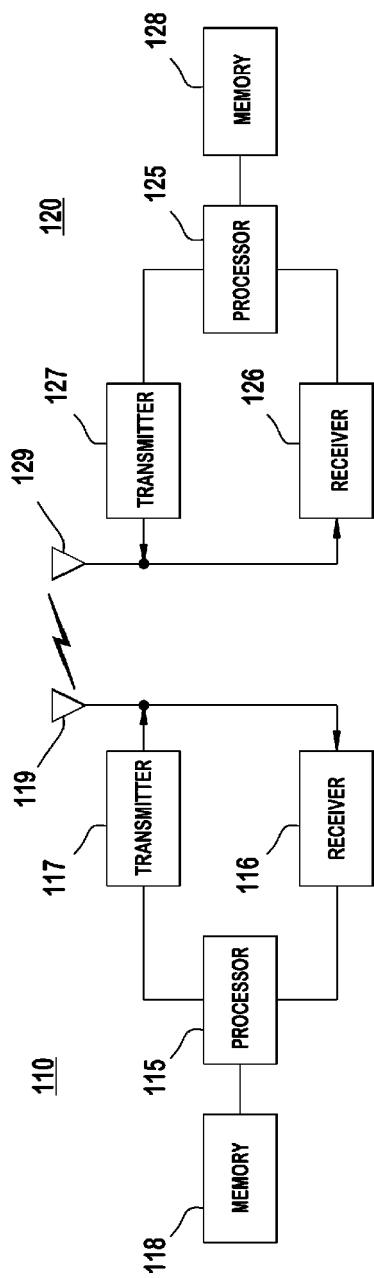


FIG. 3

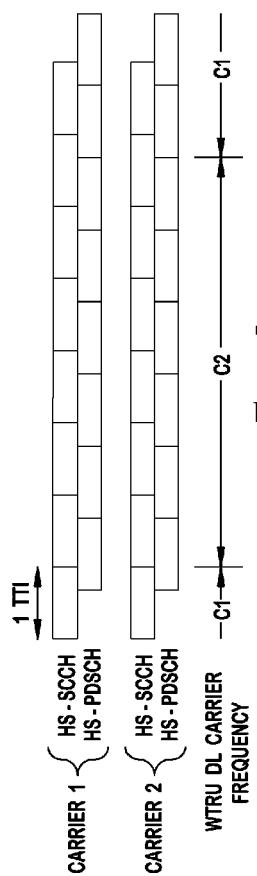


FIG. 4

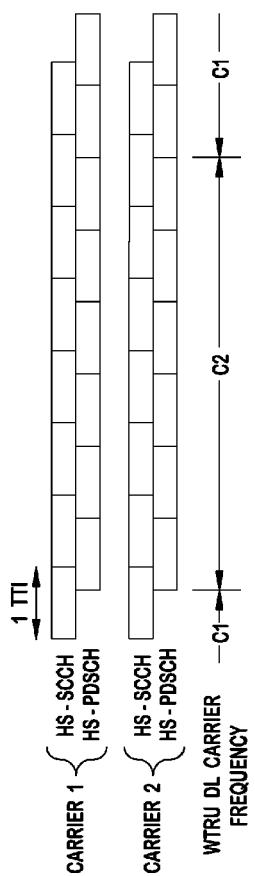


FIG. 5

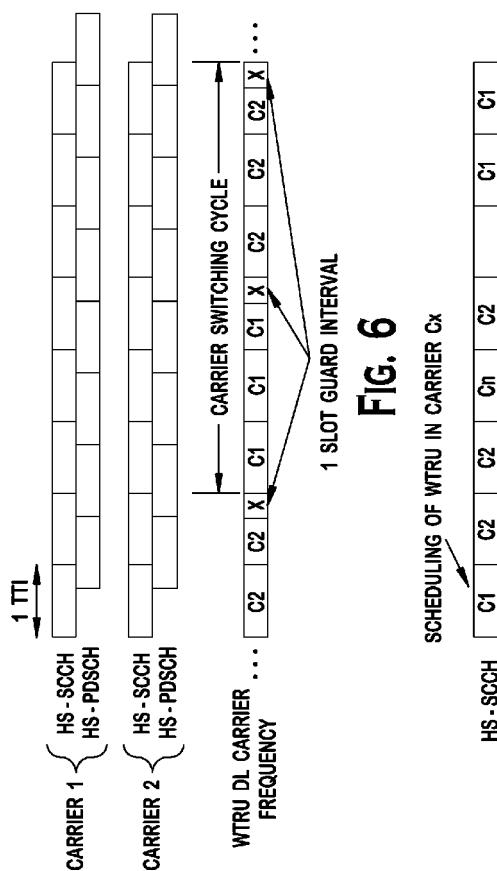


FIG. 6

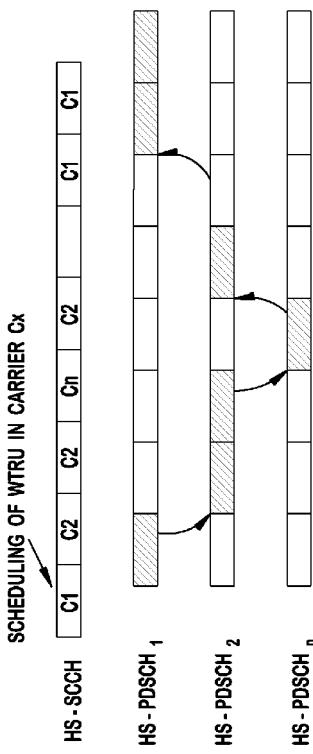


FIG. 7

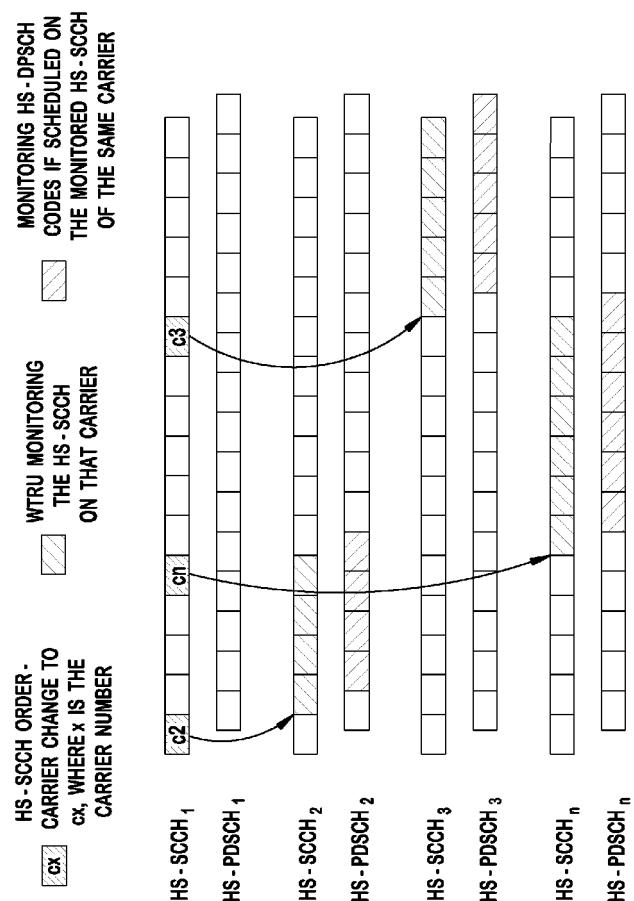


FIG. 8



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50	Place of search Munich	Date of completion of the search 13 February 2020	Examiner Martínez Martínez, V
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55	1 Place of search Munich	Date of completion of the search 13 February 2020	Examiner Martínez Martínez, V
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